STANDARD OPERATING PROCEDURE FOR TURBIDITY MEASUREMENTS USING A TURBIDITY TUBE

State of Utah
Department of Environmental Quality
Division of Water Quality

Revision 0
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Utah Division of Water Quality (DWQ) Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical experts. This document is intended primarily for internal DWQ use. This SOP should not replace any official published methods.

Any reference within this document to specific equipment, manufacturers, or supplies is only for descriptive purposes and does not constitute an endorsement of a particular product or service by the author or by DWQ. Additionally, any distribution of this SOP does not constitute an endorsement of a particular procedure or method.

Although DWQ will follow this SOP in most instances, there may be instances in which DWQ will use an alternative methodology, procedure, or process.[1]

[1] *Disclaimer language above adapted from Washington State Department of Ecology SOPs.*

REVISION PAGE

Date	Revision #	Summary of Changes	Sections	Other Comments
6/1/12	1	Not applicable	Not applicable	New SOP. Began document control/revision tracking.
5/1/14	0	Changed revision number, minor formatting	Not applicable	First version should have been revision 0

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1.0 SCOPE AND APPLICABILITY

This document presents the Utah Division of Water Quality's (DWQ) Standard Operating Procedure (SOP) for performing turbidity measurements using a turbidity tube in water columns where the use of the Secchi disk method for transparency is not practical due to excessive growth of submerged aquatic vegetation, shallow water conditions, and/or moving water or in situations where a portable turbidimeter is not available. This SOP applies to all DWQ field staff, non-DWQ cooperators, and citizen volunteers.

Turbidity is essentially a measurement of how cloudy water appears. Turbidity is technically a measure of how much light passes through water, and is a function of how suspended solid particles within the water column scatter light. These particles may be microscopic plankton, suspended sediment or organic materials, eroded soil, clay, silt, sand, mud, industrial waste, sewage, chemical precipitates or urban runoff. Therefore turbidity is a key test of water quality, and this parameter is also a key indicator used to asses the suitability of water for human consumption.

2.0 SUMMARY OF METHOD

The Turbidity Tube (also known as a Transparency Tube) is a combination of a historical method (the Jackson Candle Turbidimeter) and the Secchi Disk. The procedure is performed in the shade or the sampler uses his/her body to block the sun from shining on the tube. A water column sample is collected, avoiding surface scum and bottom sediment. Just before performing the procedure, the sampler mixes the water sample to re-suspend any sediment that has settled at the bottom of the sampling container. Next, the sampler looks down through the tube toward the black and white target disk on the bottom of the tube while pouring the water sample into the tube. The sampler stops pouring when the black and white target disk becomes invisible. The water level is recorded in centimeters (cm). The minimum detection limit of the tube is 5 Nephelometric Turbidity Units (NTU). Therefore, if the viewing disk pattern can still be seen when the tube is full, the turbidity value must be recorded as less than the final measuring mark (converting to <5 NTU). Convert from centimeters (cm) to turbidity units (NTU) using **Table 1** or **Equation 1** provided in the Data and Records Management section of this SOP.

3.0 DEFINITIONS

cm: Centimeters

EPA: Environmental Protection Agency

DWQ: Utah Division of Water Quality

NTUs: Nephelometric Turbidity Units

OSHA: Occupational Safety and Health Administration

PFDs: Personal Flotation Devices

SAP: Sampling and Analysis Plan

SOP: Standard Operating Procedure

4.0 HEALTH AND SAFETY WARNINGS

Prior to initiating field work, the field personnel must be briefed by the Field Lead on the project safety protocol. Field staff must have a working knowledge of the contents within this SOP and DWQ's safety guidance.

Field personnel should take appropriate precautions when operating the turbidity tube and working on, in, or around water, as well as possibly steep and unconsolidated banks. When working in hazardous situations, personnel should follow EPA, OSHA, and specific health or safety procedures. All proper personal protection clothing, such as waders and PFDs (personal flotation devices), and equipment should be worn.

DWQ safety guidance should be followed at all times and field personnel should always wear disposable gloves during turbidity sampling to avoid contact with potentially harmful pathogens present in the water body.

Field personnel should be aware that hazardous conditions potentially exist at every waterbody. If unfavorable conditions are present at the time of sampling, the sample visit is recommended to be rescheduled. If hazardous conditions arise during sampling, such as lightning, high winds, rising water, or flash flood warning, personnel should cease sampling and move to a safe location.

5.0 CAUTIONS

Field personnel should attempt to minimize disturbance of substrate covering the bottom of the water body (river, reservoir, wetland, etc) because this may resuspend already-settled particles which can artificially increase the turbidity in the water column and provide higher turbidity readings than the actual values. If there is a discernable flow in the waterbody, personnel should always work from downstream to upstream and wait for any disturbed substrate/sediment to settle or otherwise dissipate before taking a water column sample for the turbidity measurement.

Caution also needs to be taken on the proper handling of the turbidity tube. The tube needs to be placed in a safe place within a vehicle to prevent damage.

6.0 INTERFERENCES

Several factors may affect the turbidity readings. Since the eyesight of samplers may vary, all readings on the same waterbody ideally would be performed by the same person. Weather conditions and site conditions such as high water runoff events, vegetation growth, and animal or human disturbances can alter and affect turbidity of

the sampling locations. On the other hand, a water body may have color caused by dissolved substances or reflections from rocks and vegetation, but it is important to remember that color itself is not turbidity. Therefore, field conditions potentially affecting the measurement should be noted on the field sheet/notebook. If conditions inhibit the ability to properly sample turbidity, this should be noted in the field notebook and the site should be revisited.

7.0 PERSONNEL QUALIFICATIONS/RESPONSIBILITIES

To ensure that credible and useable data are collected, the Project Manager/Field Lead must be knowledgeable about all aspects of the project including sampling goals and objectives and quality assurance and quality control issues specific to the project-specific Sampling and Analysis Plan (SAP). The Field Lead should also check all of the work performance and verify that the work performed in the field satisfies the specific tasks that are outlined in this SOP and project-specific documents. If sampling procedures need to deviate from project-specific documents, it is the responsibility of the Field Lead to communicate this information to the field personnel.

All personnel performing turbidity sampling using a turbidity tube must read this SOP annually and acknowledge they have done so via a signature page (see **Appendix**). New field personnel must also demonstrate successful performance of the method. The signature page will be signed by both trainee and trainer to confirm that training was successfully completed and that the new monitor is competent in carrying out this SOP. The signature page will be kept on-file at DWQ along with the official hard copy of this SOP.

8.0 EQUIPMENT AND SUPPLIES

A turbidity tube is a simple device made from 1-1.75" (4.4cm) clear polycarbonate tubing with a bottom comprised of alternating white and black quadrants (black and white target disk). On the outside, the tube is marked with black numbers on a white tape. Before use, make sure the markings are still clearly visible.

_____ Copy of this SOP

_____ Turbidity tube

_____ Deionized water for rinsing tube

_____ Clean plastic half-gallon jug (State Lab provides these, referred to as “transfer” bottles) for collecting the water sample

9.0 PROCEDURE

This instrument or method does not require calibration or standardization prior to use. Instructions for using the turbidity tube are adapted from WHO guidance found at

http://www.who.int/water_sanitation_health/emergencies/envsanfactsheets/en/index1 (WHO, 2011).

Upon arrival to the sample site, establish which sampler is going to perform the turbidity measurements. To sample a water column using a turbidity tube, follow the steps below (also see **Figure 1**).

1) Rinse the tube with site water. Shake dry briefly.

2) Collect the water sample using a clean transfer bottle and grab sampling techniques (refer to DWQ's SOP for Water Chemistry Sample Collection). Always avoid surface scum and bottom sediments while collecting the water sample.

3) Move to a shaded area. If there is no shaded area, block the sun from shinning on the tube with your body.

4) Hold the tube in one hand near the bottom or set the tube on a flat work surface and look into the open end with your eyes about 10 to 20 centimeters (cm) above the tube so that you can clearly see the black and white target disk/circle on the bottom of the tube.

5) Mix the water sample gently to re-suspend any sediment that has settled to the bottom.

6) Slowly pour the water sample into the tube, waiting for air bubbles to rise, if necessary, until the black and white target disk on the bottom of the tube just disappears.

7) Once you can no longer see the disk at the bottom, stop pouring the water sample into the tube and look at the level of water in the tube. For turbidity tubes which have a scale marked on the side, record the value on the nearest line to the water level. If the tube does not have a scale marked, measure the distance from the bottom of the tube to the water level with a tape measure and convert or calculate the turbidity of the water sample using either **Table 1** or **Equation 1** or the instructions provided with the tube. **Table 1** and **Equation 1** allow you convert from centimeters (cm) to turbidity units (NTU's). If the target is visible throughout the length of the tube, record in the field notes that the measurement is greater than the measurable range (i.e. turbidity is lower than the detection limit of the tube - <5 NTU).

8) After use, rinse the inside and outside of the tube with deionized water to prevent build-up on the tube walls. Store the two parts of the tube where they cannot be damaged (World Health Organization, 2011).

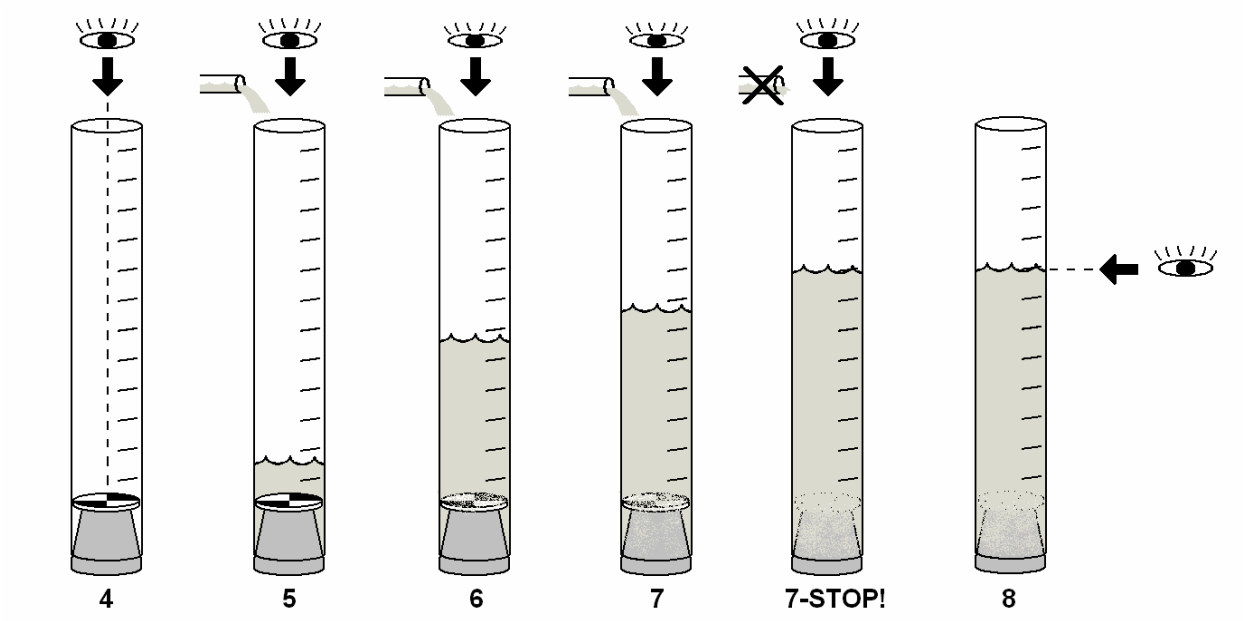

Figure 1: Schematic of turbidity measurement using a Turbidity tube
(Myre and Shaw, 2006)

10.0 DATA AND RECORDS MANAGEMENT

Turbidity readings will be converted from cm to NTU using **Table 1** or **Equation 1**. Turbidity readings (in NTU) will be recorded in the field notes or on a field sheet. Once back in the office, personnel will scan and save the field note sheets in the project folder located in the "monitors" folder on the shared drive, which is backed up daily. Hard copies of the field notes will be filed at DWQ in the appropriate project file/binder. Data management staff will review these sheets on a biweekly basis for completeness.

Equation 1: **Depth in Centimeters = 244.13 *(Turbidity in NTU)$^{-0.662}$**

Table 1: Conversion chart converting centimeters (cm) to turbidity units (NTU's).
(Source: Table and Equation 1 from Wyoming Stream Team, 2011)

Distance from bottom of tube (cm)	NTU's
<6.25	>240
6.25 to 7	240
7 to 8	185
8 to 9.5	150
9.5 to 10.5	120
10.5 to12	100
12 to 13.75	90
13.75 to 16.25	65
16.25 to 18.75	50
18.75 to 21.25	40
21.25 to 23.75	35
23.75 to 26.25	30
26.25 to 28.75	27
28.75 to 31.25	24
31.25 to 33.75	21
33.75 to 36.25	19
36.25 to 38.75	17
38.75 to 41.25	15
41.25 to 43.75	14
43.75 to 46.25	13
46.25 to 48.75	12
48.75 to 51.25	11
51.25 to 53.75	10
53.75 to 57.5	9
57.5 to 60	8
Over 60	<8

11.0 QUALITY ASSURANCE AND QUALITY CONTROL

There are limited QA/QC procedures for turbidity readings using a turbidity tube. For quality control, turbidity readings should be taken by one person for an entire sampling trip and by one person per waterbody.

Duplicate readings may be performed on sites that have duplicates established or two readings may be averaged by the sampler, if desired. Duplicate samples should be collected at a minimum rate of 1 replicate for every 20 regular samples. The duplicate sample should be collected by the same field team member who performed the associated normal sample collection. To perform the duplicate sampling, collect extra water when sampling. Clean the turbidity tube after processing the first sample using deionized water, and then perform the duplicate reading with a second aliquot of sample water following the procedures in **Section 9.0**. Note on the field note sheet that a duplicate was collected. Refer to the program/project specific SAP for performance goals for replicate measurements.

12.0 REFERENCES

World Health Organization (WHO), Water Sanitation and Health Fact Sheet on Environmental Sanitation, Fact Sheet 2.33 - Turbidity (accessed online at http://www.who.int/water_sanitation_health/emergencies/envsanfactsheets/en/index1.html on September 7, 2011).

Wyoming Stream Team, Stream Team Resources, Turbidity Instructions (PDF) (accessed online at http://wyomingstreamteam.org/resources.php on September 7, 2011).

Myre, E., & Shaw, R. (2006): The Turbidity Tube: Simple and Accurate Measurement of Turbidity in the Field, Michigan Technology University, Michigan

13.0 APPENDIX

SOP Acknowledgement and Training Form

This SOP must be read and this form signed annually. This form must be kept with the current version of the SOP.

Document Title:	
Document Revision Number:	
Document Revision Date:	

Please sign below in accordance with the following statement: "I have read and understood the above referenced document. I agree to perform the procedures described in this SOP in accordance with the document until such time that it is superseded by a more recent approved revision."

Printed Name	Signature	Date

SOP Acknowledgement and Training Form (continued)

Trainee: Sign below to acknowledge that training on this SOP was received, understood, and all questions/concerns were addressed by the trainer.

Trainer: Sign below to acknowledge that training on this SOP was completed for the individual listed and that trainee is competent to perform the procedures described within.

Date of Training	Trainee Printed Name	Trainee Signature	Trainer Printed Name	Trainer Signature